

LIGHTWEIGHT APPARATUS FOR SCREEDING  
AND VIBRATING UNCURED CONCRETE SURFACES  
CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority on U.S. provisional application, Ser. No.  
5 60/327,964, filed Oct. 9, 2001; U.S. provisional application, Ser. No. 60/341,721, filed Dec.  
18, 2001; and U.S. provisional application, Ser. No. 60/354,866, filed Feb. 5, 2002, which are  
all hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates generally to screeding devices for uncured concrete  
10 floors and surfaces and, more particularly, to a lightweight screeding device which may be  
moved and guided as a walk behind apparatus over an uncured concrete surface by hand.  
The lightweight screeding device of the present invention is particularly suited for use at both  
over ground sites as well as on elevated deck surfaces, and may be implemented at other  
uncured concrete surfaces, such as interior floors, exterior slabs, roadways, ramps, parking  
15 areas or the like.

BACKGROUND OF THE INVENTION

When forming a concrete slab or floor, the uncured concrete is placed and screeded,  
leveled and/or smoothed to obtain a generally flat slab of generally uniform thickness. One  
known method to obtain a uniform thickness of concrete of a floor or deck surface is to use  
20 small pre-fabricated metal structures or stands that have support legs, which may rest directly  
on the corrugated sheet metal decking or plywood form-work. A small plate may be held in  
position at the height equal to the desired concrete thickness above the metal deck or form  
work. The manual screeding process then relies on these stands as a height gauge. Some  
devices may even ride along the top surface of elongated stands or rails supported by the  
25 stands similar to known methods used for slabs-on-grade and elevated deck work prior to  
implementation of mechanized laser screeding. The stands or rails may be removed just after  
the screeding process completed and before the concrete begins to cure. Any remaining holes  
and imperfections are then filled and refinished before the concrete begins to fully harden.

Another known method for obtaining a uniform thickness of concrete on a floor or  
30 deck is to provide an ongoing series of small pre-screeded areas ahead of the actual screeding  
process. These small pre-screeded areas may be generally referred to or known as "wet pads".

A hand trowel may be used to strike off a roughly twelve inch (30 cm) diameter area of the pre-placed concrete at a desired height or elevation. The height or elevation of each "wet pad" may be determined by using a pre-established laser reference plane provided by a laser transmitter set-up at the site, and a hand-held laser receiver mounted to a pre-set position on a grade-stick. A series of small "wet pads" or "surface pads" are thus created at the desired thickness or elevation of concrete which serve as temporary height gages. A manual hand-screeding method will use a series of these pads as a reference.

As a typical example of the procedure, first, two wet pads are made about ten feet apart. Then, a wooden 2 x 4 or similar straight edge is used to strike off approximately a 12 inch (30 cm) wide by 10 foot (3 m) long surface between the two twelve inch (30 cm) diameter pads. Two of these 12 inch (30 cm) wide by 10 foot (3 m) elongated "surface-pads" are then struck off parallel to each other at a distance roughly equal to the width of the screed being used. The concrete is then struck off between these two parallel surfaces using the elongated "surface-pads" as a height reference or guides for the screed. Any excess concrete material may then be manually raked and shoveled aside by workers. Alternately, additional concrete material may be brought in and added as needed to fill any low areas. This is accomplished by at least one and often two or more workers. Any obvious low or high areas are thus detected through ongoing visual inspection by the workers and corrections to the concrete elevation or thickness are made in anticipation of the action of the screeding device. This process is subject to a number of variables which affect the quality of the surface of the concrete, including human effort and error.

Hand screeding devices are known where a vibratory device is moved over a concrete surface by hand. Examples of such devices are disclosed in U.S. Patent No. 3,067,656 issued to Gustafsson; 5,244,305 issued to Lindley; and 5,857,803 issued to Davis et al. However, such known screeding devices typically require any grade elevation or thickness adjustments of the concrete surface to be performed by manually raking or pre-grading the uncured concrete surface to a desired grade prior to screeding the surface with the vibratory screeding device. The manual human effort and visual inspection process typically results in a concrete surface that is subject to undesired height or elevation variation. This directly affects the quality of the finished concrete surface and is measurable in terms of scientifically accepted standards known in the industry as "Floor Levelness" (F-l) and "Floor Flatness" (F-f).

Therefore, there is a need in the art for an improved screeding method and apparatus or device, which is relatively small and maneuverable, for providing a concrete slab or deck

of generally uniform thickness or elevation without requiring the additional manual labor processes associated with metal stands, wet pads, pre-grading, or the like.

### SUMMARY OF THE INVENTION

The present invention provides an apparatus for screeding and vibrating uncured  
5 concrete, sand, dirt, gravel and/or other materials in areas which may be inaccessible to larger machines and equipment, such as due to the space limitations of small buildings, or the weight restrictions maintained during the construction of elevated decks and surfaces. The present invention provides a concrete strike-off and screeding device or screed head which is moved around through human effort and/or through the force of a driven wheel or wheels.

10 The screed head includes a concrete surface working member or device, such as a vibrating member or beam, and a grade setting device or member. The vibrating member is an generally elongated horizontal member having a surface area in contact with the surface of the uncured concrete. The grade setting device or member is a generally elongated horizontal member located in close proximity, just ahead of, and in parallel with the vibrating member.

15 The grade setting device may be constitute a variety of forms, such as a strike-off plow, an auger, a flexible belt or chain with attached paddles, a spinning tube, or other such devices or forms for the purpose of engaging and imparting the movement of uncured concrete. The grade height or elevation of the grade setting device is adjustable via mechanical adjusting devices or electromechanical actuators which are preferably operable to automatically adjust  
20 an elevation of the grade setting device to a pre-determined desired elevation according to an electronically-sensed laser plane reference. A pair of laser receivers are mounted to the grade setting device and are operable to sense or detect the elevation position of the grade setting device relative to the laser plane.

The vibrating member generally floats upon or is supported directly on the uncured  
25 concrete surface created by the grade setting device ahead of it. With the grade setting device and laser receivers fixed together and adjustably attached to the vibrating member, the laser receivers and automatic control system automatically react to adjust the elevation of the grade setting device with respect to the newly and continuously created surface and with respect to the laser plane reference. This ongoing reference is used to correct the elevation of the grade  
30 setting device as the machine advances over and through the uncured concrete.

For example, when the screeding apparatus is operating and producing a concrete surface to a desired "on grade" result, the relative height of the grade setting device as compared to the vibrating member remains effectively unchanged by the control system. Alternately, if the concrete surface produced by the machine, and upon which the screed head

and laser receivers is riding, is too high, the laser receivers will indicate a “high” signal to the control system. This “high” signal is then used by the control system to send a signal to the respective elevation actuator and accordingly lower the grade setting device, quickly working to produce a concrete surface at the correct elevation. Conversely, if the concrete surface produced by the machine, and upon which the screed head and laser receivers is riding, is too low, the laser receivers will indicate a “low” signal to the control system. This low signal is then used by the control system to send a signal to the respective elevation actuator and accordingly raise the grade setting device, quickly producing a concrete surface at the correct elevation. In either corrective operating mode, and within the operating range of the laser receivers, the corrective action will be a continuous process until the correct elevation is reached by the laser receivers and screed head.

The present invention thus provides a self-correcting process along with the ability of the apparatus to be at least partially supported upon the desired correct elevation surface it creates, as the device itself advances.

According to an aspect of the present invention, a screeding device which is movable over a surface of uncured concrete and is operable to level and smooth the uncured concrete surface includes a concrete surface working member and a grade setting device. The grade setting device is adjustably mounted to the concrete surface working member and is generally vertically adjustable with respect thereto. The concrete surface working member is at least partially supported on the uncured concrete surface, while the grade setting device is adjustable relative to the concrete surface working member to at least one of establish and indicate a desired grade for the uncured concrete surface. The grade setting device thus causes the concrete surface working member to flatten, smooth, and/or consolidate the uncured concrete surface at the desired grade. The height or grade of the grade setting device is preferably adjustable in response to a laser leveling or laser reference system.

Preferably, the concrete surface working member comprises a vibrating member or beam which is vibratable to flatten, smooth and consolidate the uncured concrete while being partially supported thereon. However, the concrete surface working member may comprise a roller, a flat or contoured plate or pan, a roller track or the like which is operable to engage and work the uncured concrete surface as the screeding device is moved over, along and/or through the uncured concrete.

In one form, the grade setting device of the screeding device includes a strike-off member or plow which functions to strike off the uncured concrete to establish the desired elevation or grade as the screeding device is moved over the uncured concrete surface. In

another form, the grade setting device includes an elongated member or tube, which further includes a plurality of fingers or extensions extending downwardly therefrom for indicating the desired grade height above the sub-grade, thereby allowing for a reduced need for creating "wet pads". Either the lack of contact or marks left in the concrete by the fingers or extensions would show where additional manual filling, or pre-leveling of the concrete surface by workers using concrete rakes or shovels may be desired or necessary.

Optionally, the screeding device may include a means for moving excess concrete from in front of the grade setting device to either or both sides, or just ahead of the screeding device as the screeding device is moved through the uncured concrete. The means for moving excess concrete is preferably positioned along the forward face of the grade setting device to engage any excess concrete in front of the plow and to help fill in any low areas as well. The means for moving excess concrete may comprise an auger, a flexible belt or chain with paddles or the like, a rotating or spinning tube, a secondary plow or strike-off member, or any other means for moving excess concrete to one, both sides, or just ahead of the screeding device, while the device is moved along and through the uncured concrete. Optionally, the grade setting device may comprise a means for moving excess concrete and may function to cut and establish the grade height of the concrete surface in front of the vibrating member.

The screeding device is powered via a power source, which may include an internal combustion engine or an electric motor or any other powered means. The power source is operable to provide power to the vibrating member and the adjusting devices or actuators.

Optionally, the screeding device includes a wheeled support frame for partially supporting at least some of the components of the screeding device. The wheels of the support frame may be powered or rotatably driven to assist an operator in moving the screeding device over the uncured concrete surface. The vibrating member and grade setting device together generally comprise a screeding head. The screed head may be adjustably mounted to the wheeled support frame and may be adjustable to change and adjust an operating range height or grade of the screed head relative to the wheeled support frame. The screed head may also be adjustably mounted to the wheeled support frame to change or adjust a pitch or "angle of attack" of the screed head relative to the wheeled support frame and the uncured concrete surface. In addition to operating range height and pitch adjustments, a means to temporarily raise and then lower the screed head relative to the support frame in order to clear any low obstacles while moving the apparatus to and from or around the work

site may also be provided. Any temporary raising and lowering of the screed head is not intended to affect any established operating range height and pitch adjustments.

According to another aspect of the present invention, a method of flattening or leveling, smoothing and/or screeding, and/or consolidating an uncured concrete surface  
5 includes providing a screeding device which includes a concrete surface working member and a grade setting device, which is adjustable relative to the concrete surface working member. The screeding device is moved over the uncured concrete surface while the concrete surface working member is at least partially supported on the uncured concrete surface. The grade setting device is adjusted relative to the concrete surface working member  
10 to at least one of establish and indicate a desired height or grade for the uncured concrete surface.

Preferably, the concrete surface working member comprises a vibrating member or beam which is vibratable to flatten, smooth and consolidate the uncured concrete while being partially supported thereon. The method then includes vibrating the vibrating device while  
15 the vibrating device is at least partially supported on the concrete surface.

The grade setting device may include a visual indication of the desired grade height or may include a strike-off plow, auger or the like for plowing or cutting the uncured concrete to establish the desired grade height as the screeding device is moved over or through the uncured concrete surface.

20 In one form, the screeding device is moved over the uncured concrete surface by manually pulling the screeding device while the screed head, including the vibrating member and grade setting device, and a portion of the screeding apparatus itself, is supported by the uncured concrete surface. In another form, the screeding device includes a wheeled support frame for partially supporting at least some of the weight of the components of the screeding  
25 apparatus. Optionally, the wheels of the support frame may be powered or driven to assist an operator in moving the screeding device over or through the uncured concrete surface.

The grade setting device may also include a concrete moving device for engaging and moving any excess concrete and to help fill in any low areas as well. The means for moving excess concrete may comprise an auger, a flexible belt or chain with paddles or the like, a  
30 rotating or spinning tube, a secondary plow or strike-off member, or any other means for moving excess concrete to one, both sides, or just ahead of the screeding device, while the device is moved along and through the uncured concrete.

According to another aspect of the present invention, a wheeled screeding device which is movable over or through a surface of uncured concrete and is operable to level,

smooth, and consolidate the uncured concrete surface includes a wheeled support, a screed head and an adjustment device. The wheeled support includes a frame portion supported by at least one wheel. The at least one wheel defines an axis of rotation of the wheel and a general axis of rotation for the apparatus itself. The screed head is mounted to the frame portion and is at least partially supportable on an uncured concrete surface. The screed head is adapted to impart a force onto the uncured concrete surface. The adjustment device is operable to adjust a desired degree of weight distribution and balance of the apparatus. Therefore, the balance of the apparatus about the axis of rotation at the wheeled support is used to adjust the force imparted by the screed head onto the uncured concrete surface.

In one form, the adjustment device includes the addition or removal of at least one weight at one or both ends of the wheeled support or anywhere along the longitudinal axis of the apparatus for adjustment purposes. In another form, the adjustment device is operable to mechanically adjust a position of the axis of rotation relative to the frame portion and the center of gravity of the apparatus.

The screed head may include a vibratable beam or member, a grade indicating device, a grade setting device, such as a strike-off plow or the like, and a means for moving excess concrete which is operable to move excess concrete to one side, both sides or just ahead of the vibratable member and to help fill in any low areas as well. The means for moving excess concrete may comprise an auger, a flexible belt or chain with paddles or the like, a rotating or spinning tube, a secondary plow or strike-off member, or any other means for moving excess concrete to one, both sides, or just ahead of the screeding device, while the device is moved along and through the uncured concrete.

According to yet another aspect of the present invention, a wheeled screeding device which is movable over a surface of uncured concrete and which is operable to level, smooth, and consolidate the uncured concrete surface includes a wheeled support and a screed head. The wheeled support includes a frame portion movably supported on at least one wheel. The at least one wheel defines an axis of rotation of the wheel and an axis of rotation for the apparatus itself. The screed head is mounted to the frame portion and is at least partially supportable on an uncured concrete surface. The screed head is also pivotable about a second axis generally horizontal and normal to the first axis of rotation and relative to the at least one wheel to adjust an angle of the screed head relative to the axis of rotation. The second axis of rotation provides the screed head with the capability of a clockwise and/or counterclockwise or roll freedom of movement relative to the surface of the uncured concrete and is generally parallel to the direction of travel of the apparatus.

In one form, the screed head is pivotable relative to the frame portion. In another form, the screed head is pivotable with the frame portion, which is pivotable relative to the axis of wheel rotation.

According to another aspect of the present invention, a method of smoothing,  
5 screeding, and consolidating an uncured concrete surface includes providing a wheeled screeding apparatus which includes at least one wheel and a screeding device mounted at the at least one wheel. The at least one wheel is movable through an uncured concrete surface. The screeding apparatus is adjustably and proportionately balanced about the at least one wheel such that the screeding device is at least partially supported on the uncured concrete  
10 surface and at least one wheel. The method includes moving the wheeled screeding apparatus over and/or through the uncured concrete, and screeding the uncured concrete surface with the screeding device while the screeding device is at least partially supported on the uncured surface.

Optionally, the method may include adjusting the wheeled screeding apparatus to  
15 adjust a degree or proportion in which the screeding device is supported on the uncured concrete surface.

Therefore, the present invention provides a lightweight, easily maneuverable screeding device which is at least partially supported on the uncured concrete as it is moved over or through the uncured concrete surface by an operator. The relative small size and  
20 portability of this device makes it uniquely useful for many concrete construction site applications. The screeding device includes a plow or other grade setting element or device which is vertically adjustable relative to a concrete surface working member or vibrating member of the screeding device to adjust the grade setting device to the desired grade height as the screeding device is moved over and supported on the uncured concrete surface. The  
25 screeding device includes an automatic control system which is responsive to a laser plane or laser-guided reference for vertically adjusting the grade setting device to the desired grade height. The screeding device may include a wheeled support which may be powered to drive one or more wheels to move the screeding device over and through the uncured concrete. In addition to reducing labor and effort, the present invention also provides for improved  
30 accuracy of the screeded concrete surface through the use of an automated control system and on-site laser reference for controlling the elevation adjustment of a grade-setting device. This occurs in conjunction with and just prior to the action of the vibratory screeding element supported by the uncured concrete.



These and other objects, advantages, purposes and features of this invention will become apparent upon review of the following specification in conjunction with the drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5           FIG. 1 is an upper perspective view of a screeding device in accordance with the present invention;

          FIG. 2 is a rear end elevation of the screeding device of FIG. 1;

          FIG. 3 is a top plan view of the screeding device of FIGS. 1 and 2;

          FIG. 4 is a side elevation of the screeding device of FIGS. 1-3, as it is moved by an  
10   operator;

          FIG. 5 is an enlarged perspective view similar to FIG. 1;

          FIG. 6 is an enlarged perspective view of the area VI in FIG. 5;

          FIG. 7 is an enlarged perspective view of the area VII in FIG. 5;

          FIG. 8 is an enlarged side elevation similar to FIG. 4;

15           FIG. 9 is an enlarged perspective view of a vibrating device with eccentric weight members useful with the screeding device of FIGS. 1-8;

          FIG. 10 is an upper perspective view of another screeding device in accordance with the present invention;

          FIG. 11 is a lower perspective view of the screeding device of FIG. 10;

20           FIG. 12 is an upper perspective view of another screeding device in accordance with the present invention, with a wheeled frame structure;

          FIG. 13 is a side elevation of the screeding device of FIG. 12 in use by an operator;

          FIG. 14 is a top plan view of the screeding device of FIGS. 12 and 13;

          FIG. 15 is a front end elevation of the screeding device of FIGS. 12-14;

25           FIG. 16 is an upper, rear perspective view of another screeding device in accordance with the present invention, with a wheeled frame structure;

          FIG. 17 is an upper, front perspective view of the screeding device of FIG. 16;

          FIG. 17A is an upper, front perspective view similar to FIG. 17, with the power source omitted to reveal additional details of the wheeled support;

30           FIG. 17B is an enlarged perspective view similar to FIG. 17A, with the screeding head omitted for clarity;

          FIG. 18 is a side elevation of the screeding device of FIGS. 16 and 17 in use by an operator;

          FIG. 19 is a top plan view of the screeding device of FIGS. 16-18;

FIG. 20 is a front end elevation of the screeding device of FIGS. 16-19;

FIG. 21 is an enlarged perspective view of a vibrating device with eccentric weight members useful with the screeding device of FIGS. 16-20;

FIG. 22 is another enlarged perspective view of the vibrating device of FIG. 21, with  
5 a housing around the eccentric weight members;

FIG. 23 is an upper, front perspective view of another screeding device in accordance with the present invention, with an auger mounted forward of the plow and vibrating member;

FIG. 23A is an upper, front perspective view of the screeding device of FIG. 23,  
10 shown with a 3-D profiler contouring system including a sonar height sensor and a laser reflective tracking target, and wheel track filler members just rearward of the wheels;

FIG. 24 is an upper, front perspective view of yet another screeding device in accordance with the present invention, with a belt and paddle device adjustably mounted along a forward edge of the vibrating member;

FIG. 25 is an upper, front perspective view of another screeding device in accordance with the present invention, with a spinning tube device adjustably mounted forward of the vibrating member;

FIG. 26 is an upper, front perspective view of another screeding device in accordance with the present invention, with a single wheeled support;

FIG. 27 is an upper, front perspective view of yet another screeding device in accordance with the present invention, with a housing around the components carried on the wheeled support;

FIG. 28 is an hydraulic schematic diagram exemplary of an hydraulic control system useful with a screeding device of the present invention;

FIG. 29A is a perspective view of another concrete working device in accordance with the present invention;

FIG. 29B is a side elevation of the concrete working device of FIG. 29A;

FIG. 29C is a top plan view of the concrete working device of FIGS. 29A and 29B;

FIGS. 30A-C are views and elevations similar to FIGS. 29A-C of another concrete  
30 working device in accordance with the present invention; and

FIGS. 31A-C are views and elevations similar to FIGS. 29A-C of another concrete working device in accordance with the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now specifically to the drawings and the illustrative embodiments depicted therein, a screeding device 10 includes a screeding head 11, which includes a grade setting or indicating device, such as a strike-off plow 12, and a vibratory beam or member 20 (FIGS. 1-8). Plow 12 is attached to a framework 14 by two small sets of linkages 16 and is vertically adjustable relative to the framework 14 by a pair of elevation actuators 18 (FIGS. 1-8).

Vibratory beam or member 20 is mounted to the framework 14. Screeding device 10 is at least partially supported on an uncured concrete surface and moved along and over the concrete surface to screed and smooth the surface via vibration of the vibrator beam 20 as the vibrator beam 20 floats on or is at least partially supported on the uncured surface. The plow 12 is adjustable with respect to the vibrator beam 20 to adjust a level or grade of the uncured concrete to a desired grade as screeding device 10 is moved along and over the uncured concrete.

Plow 12 includes a plow blade or edge 12a and a generally rigid structural member or metal extrusion 12b extending laterally along the blade 12a (FIGS. 7 and 8). The structural member 12b provides a mounting surface for mounting plow 12 to the linkages or actuators, as discussed below, and provides structural rigidity to plow 12 to limit or substantially preclude deflection of plow 12 as plow 12 engages the uncured concrete. The blade 12a and casing 12b of plow 12 and/or other components or elements of the plow may be welded or riveted together or may be otherwise secured together via any other means, such as a double sided adhesive tape, such as VHB adhesive tape available from 3M Scotch Brand of the 3M Company of St. Paul, Minn., USA, or the like, without affecting the scope of the present invention.

Vibrator beam or member 20 is a generally flat member extending laterally outwardly in opposite directions from a pair of frame members 14d of framework 14. Vibrator beam 20 may be any vibratable member and preferably has a generally planar, flat and smooth lower surface for engaging and working the uncured concrete surface. In the illustrated embodiment, vibrating beam 20 extends along a longitudinal axis 20a and includes a lower, generally flat planar portion 20c and a pair of generally vertical walls 20d extending therealong to strengthen the planar portion and limit or substantially preclude deflection of the beam (FIG. 1). Similar to plow 12, discussed above, the components of vibrator beam 20 may be welded or riveted together or may be otherwise secured together via any other means, such as a double sided adhesive tape, such as "Scotch VHB" (Very High Bond) adhesive tape available from the 3M Company of St. Paul, Minn., USA or the like, without affecting the

scope of the present invention. The length and width of vibrator beam 20 may be selected to provide a large enough footprint of the lower surface of the beam such that vibrator beam 20, along with the screeding device 10, floats on or is at least partially supported on the uncured concrete surface. Although shown and described as having a vibrating beam, the screeding  
5 device and/or screed head may alternately include any other type of concrete surface working device or member, such as a roller, a flat or contoured plate or the like, which engages and works the uncured concrete surface to flatten and/or smooth the concrete surface as the screeding device is moved over and along the uncured concrete.

The levelness or curvature of the plow and/or the vibrator beam may be adjustable to  
10 maintain or adjust the contacting or engaging surface at a generally straight or level orientation, in order to further limit or substantially preclude deflection of the beam. This may be accomplished by adjustable tensioning cables and/or rods extending along the plow and/or beam, such as by using the principles disclosed in U.S. Pat. No. 5,234,281 for DEFLECTION INDICATING ADJUSTABLE HIGHWAY STRAIGHT-EDGE, which is  
15 hereby incorporated herein by reference.

Plow 12 is adjustable relative to vibrator beam 20 via pivotal movement of linkages 16 and in response to actuators 18. Linkages 16 and actuators 18 are mounted to a pair of side frame members 14d, as best seen in FIGS. 5, 7 and 8. The actuators 18 control the vertical elevation of the plow 12 in relationship to the framework 14 and vibrator beam 20 via  
20 pivoting of the linkages 16 relative to plow 12 and framework 14. Because the actuators are generally fixedly mounted to the frame members 14d and, thus, to the vibrator beam 20, actuation of the actuators functions to lower or raise the plow relative to the vibrator beam. The actuators 18 are powered by a power supply, such as a 12-volt DC electrical power source, such as an alternator 36 including an AC to DC power converter and a voltage  
25 regulator (not shown). Optionally, the actuators may be any other means for raising or lowering the plow relative to the vibrator beam, such as hydraulic cylinders or the like, without affecting the scope of the present invention. The position or amount of extension of each actuator 18 may be independently adjusted, such as through a range of approximately 4 inches (100 mm), and may be controlled by output signals from an onboard electronic control  
30 box 21 (FIGS. 1, 3, 4 and 8).

The parallel linkages 16 function to maintain horizontal attachment of the plow 12 to the framework 14 as the plow is raised or lowered by the actuators 18. As best seen in FIGS. 7 and 8, each set of linkages 16 includes a pair of generally parallel links 16a, 16b, which are pivotally mounted to side frame member 14d at one end and to a generally vertical link 16c at

the other end. Vertical link 16c is secured to a rear portion of the plow 12. Actuators 18 are connected to generally vertical link 16c and function to raise and lower vertical link 16c and plow 12 in a generally vertical, linear, reciprocal direction by pulling or pushing link 16c toward or away from the actuator, while links 16a, 16b function to maintain the plow in its generally vertical orientation during such reciprocal movement via pivotal movement of links 16a, 16b relative to frame member 14d and center link 16c. The linkages 16 thus limit or substantially preclude pivotal movement of the plow as it is vertically adjusted by actuators 18, such that plow 12 remains generally parallel to vibrator beam 20 regardless of the vertical position of plow 12 relative to vibrator beam 20.

The side frame members 14d of framework 14 are connected together by a pair of generally parallel rods or members 15 extending generally along the plow 12 and vibrator beam 20. The rods 15 are further secured to a central frame portion 14b of framework 14, which extends upwardly from the plow 12 and vibrator beam 20 for mounting a vibrator drive motor or power source 30 and for providing an operator control handle 14a and a lifting handle 14c for screeding device 10.

Vibration of vibrator beam 20 is accomplished by a powered vibrator device 31, which is powered by power source 30 (FIGS. 1, 6, 8 and 9), such as a gasoline powered drive motor or engine, or a battery powered drive motor, or the like. As shown in FIG. 9, vibrator device 31 includes a pair of eccentric weight shafts or members 32a, 32b, which are rotatably driven via a flexible drive shaft 34 from power source 30. Flexible drive shaft 34 is operatively connected to one of the eccentric weight members (such as member 32a) with spur gears or the like (not shown) to rotatably drive eccentric weight member 32a.

As shown in FIG. 9, eccentric weight members 32a and 32b include an eccentrically weighted portion 32c, which is offset from the central axis of rotation, and a circular portion 32d with gear teeth 32e, which is concentrically mounted on the central axis of rotation. Eccentric members 32a, 32b are engaged together via gear teeth 32e, such that rotation of one eccentric weight member 32a about its central axis of rotation rotatably drives the other eccentric weight member 32b in the opposite direction about its respective central axis of rotation. The rotation of the eccentric weight members 32a, 32b causes the vibration in the beam 20 to be directed to act in a primary axis matching the elongated axis 20a (FIG. 1) of the vibrator beam 20, while also serving to reduce or cancel vibration in the horizontal axis perpendicular to the vibrator beam 20. The eccentric weight members thus allow the vibration to be tailored in a desired plane, while substantially precluding vibration in an undesired plane.

Each of the eccentric weight members 32a, 32b is mounted between a pair of bearing members 38a, 38b, which are mounted (such as bolted or welded or the like) to a respective one of upper and lower mounting plates 40a, 40b (FIG. 9). As shown in FIGS. 5 and 6, the lower mounting plate 40b is then mounted between a forward plate 42a and a rearward plate 42b of the vibrator beam 20 via a pair of fasteners or bolts 44 extending through a pair of generally cylindrical mounting members 40c of lower mounting plate 40b. The lower mounting plate 40b, and thus the vibrator beam 20, is also mounted to lower brackets or plates 46, one on each of the central frame portions 14b, via one or more rubber sandwich mounts 28 (such as four in the illustrated embodiment), which also help serve to dampen the transmission of beam vibration to the support frame 14 and operator handle 14a of screeding device 10.

In the illustrated embodiment, vibrator power source 30 is an internal combustion engine. Optionally, however, the power source 30 may include an electric drive motor, such as a battery powered motor or the like. For example, the operator using the screeding device may carry a battery pack for powering the vibrator device. The battery pack may include a motorcycle battery or the like or a Nickel Metal Hydride pack or the like, or any other power source which provides sufficient power for driving the vibrator device 31. Such a battery pack may provide a sufficient power source for the vibrator device, while reducing the weight of the screeding device and also providing a quieter vibrator device. Alternately, the screeding device of the present invention may also be electrically powered through use of a power supply cable connected to a remote electric power supply. It is further envisioned that compressed air may be utilized to power the vibrating means of the vibrator device 31 and the elevation actuators through electrically controlled solenoid air valves. Therefore, the present invention may be operable via any power means, such as via an internal combustion engine, electrically via a power cord or battery, and/or pneumatically via a compressed air source and hose, or any other means for providing power to the components of the screeding device, without affecting the scope of the present invention.

The elevation of the plow 12 is adjustable relative to the beam 20, preferably in response to a laser plane system. Optionally, and preferably, the control box 21 for controlling the actuators 18 receives input signals from each of a pair of laser receivers 22 (FIGS. 1-4), which each sense the elevation of a fixed laser plane reference 24 (FIG. 1) that has been established over the job site by a separate rotating, laser plane generator or projector (not shown), as is commonly known in the industry. Each laser receiver 22 is mounted to a support rod or mast 26 which is in turn mounted to the grade setting device or strike-off plow

12. Laser receivers 22 may be any suitable type of laser receiver, such as a Spectra Precision “R2N” , “GCR”, or Combi CR600 laser receiver available from Trimble Engineering and Construction Division of Dayton, Ohio, USA, or the like. The laser receivers may be adjustably mounted to masts 26 or the masts may be telescoping masts to facilitate vertical adjustment of the laser receivers relative to the grade setting device or plow. The masts 26 and laser receivers 22 of the laser plane system may be positioned toward laterally outward ends of the plow (as shown in FIGS. 1-3) or, alternately, toward a center region or centerline, where they are generally aligned and in-line with the actuators 18 (as shown in FIGS. 10 and 11 and as discussed below) in order to accommodate the relative response of the laser-controlled elevation actuators and control system. Optionally, the closed-loop system response may be changed electronically, such as by adding an adjustable potentiometer or variable capacitor to the control circuits, without affecting the scope of the present invention. Optionally, the elevation of plow 12 may be manually adjusted during operation by the operator, such as via mechanical adjustments or override electrical control actuation of actuators 18, without affecting the scope of the present invention.

An electric alternator 36 (FIGS. 1, 5 and 6), which is driven by the engine 30 and flexible shaft 34, provides electrical power to the laser receivers 22, an elevation control, control box 21, electrical circuit (not shown), and plow elevation actuators 18. As shown in FIGS. 1-3, 5 and 6, alternator 36 may be positioned at a lower portion of the framework 14 and at a central portion of the beam 12 and plow 20. Optionally, the alternator, dynamo, or generator 36 may be incorporated into the design of the internal combustion engine, without affecting the scope of the present invention.

Screeding device 10 is movable and operable by being pulled by human effort (in the direction of arrow A as shown in FIG. 4) over and/or through freshly poured and uncured concrete. Laser receivers 22 are set to sense or detect the established laser plane reference 24, such that the height of the desired concrete grade is established by the strike-off plow 12, which is vertically adjusted relative to vibrator beam 20 in response to the laser receivers 22 and actuators 18. The floating action of the vibrator beam 20 over the uncured concrete then continues to consolidate, smooth, level and finish the uncured concrete surface. Should laser receivers 22 sense a laser plane signal 24 that is either high or low, an output signal from the control box 21 automatically adjusts the appropriate elevation actuator or actuators 18 to correct the elevation of the plow 12, returning the plow to the desired grade.

Many components of screeding device 10 are preferably made from aluminum using known methods of fabrication and materials including commercially available dimensional

metal stock, extrusions, castings, or machined components and other lightweight materials. The illustrated embodiment of FIGS. 1-9 of the present invention preferably weighs approximately 60 lbs. (27.2 kg.), but may weigh more or less than this, without affecting the scope of the present invention. This makes the device portable and manageable by one  
5 operator or worker. Further weight reduction or even an increase in size and capacity of the device without adding additional weight or without adding a significant amount of weight is possible through the use of even lighter materials such as magnesium, plastic, or carbon fiber composites.

Plow 12 and vibrator beam 20 are preferably of such length to allow and enable the  
10 screeding device 10 to be easily maneuvered by a single operator. Various lengths and/or sizes of the screed head are available for the device and easily interchanged as needed. For example, the plow and beam may be approximately six feet (183 cm) or less, which is a manageable length, yet the surface area of the vibrator is of such design and dimension that there remains a sufficiently low contact pressure on the concrete surface. However, other  
15 lengths may be implemented as desired for specific working applications without affecting the scope of the present invention. Preferably, the length of the screed head is selected to be short enough to allow for easy maneuverability and handling and not so long as to avoid excessive labor during use through raking large amounts of material in advance of the plow or grade setting device.

20 Optionally, the plow and vibrating beam may have adjustable lengths so as to be adaptable for different applications. For example, the plow 12 and vibrating beam 20 may include bolt-on sections 12c, 20b (FIG. 1), respectively, of different sizes, or may include other extensions or wings, which may be bolted to either or both ends of a central, shorter plow and beam. This allows the operator to vary the length of the plow and beam (and thus  
25 the width of the screeding device) depending on the particular application. For example, the lengths of the vibrating beam and plow may be adjusted between approximately three feet and approximately twelve feet via attachment or detachment of various sections. Optionally, the rotational speed of the vibrating members and the mass and sizes of the eccentric weights may be adjustable to accommodate different length beams and/or plows.

30 Referring now to FIGS. 10 and 11, a screeding device 110 is shown which is substantially similar to the screeding device 10, discussed above. Screeding device 110 includes a screeding head 111, which includes a vibrator beam 120 and a grade setting or grade indicating device 112. As best shown in FIG. 11, grade indicating device 112 includes an elongated member or tube 113a which further includes a plurality of indicators, such as



fingers or extensions 113b, spaced along the lower surface of the tube 113a and extending downwardly therefrom. Grade indicating device 112 is adjustable relative to vibrator beam or member 120 in response to actuators 118 and a control 121 to indicate to an operator of screeding device 110 the desired grade of the uncured concrete surface. Either a lack of  
5 contact or marks left in the concrete by the fingers or extensions 113b may indicate an area or areas where additional manual filling, or pre-leveling of the concrete surface by workers using concrete rakes or shovels may be necessary or desired.

Screeding device 110 also includes a pair of laser receivers 122 mounted to generally vertical rods 126, which are in turn mounted to elongated tube 113a, with the laser receivers  
10 122 and rods 126 being mounted to tube 113a toward a central portion of screeding device 110, rather than at the outer ends of the grade setting device, as shown in FIGS. 1-3 with respect to screeding device 10. In the illustrated embodiment, the rods 126 are positioned and aligned to be generally in-line with the elevation actuators 118. As discussed above, positioning the rods and laser receivers in this manner effectively accommodates for the  
15 relatively quick system response of the laser-controlled elevation actuators 118, in order to enhance control of the height of tube 113a and fingers 113b relative to vibrator beam 120.

Preferably, the fingers 113b of tube 113a are generally straight wire fingers spaced approximately one to two inches apart along the tube and extending generally vertically downward therefrom, with the bottom of the fingers terminating at the desired grade when  
20 the elongated tube is set at the appropriate level. The fingers 113b may be substantially rigid or they may be flexible and may flex as they contact the uncured concrete surface. The fingers 113b thus provide a visual indication of the desired grade to the operator and workers, but do not necessarily function to plow or rake to move substantial amounts of material as screeding device 110 is pulled or moved over the concrete. Fingers 113b may be suitable for  
25 wider screeding devices where the additional weight of having a wider plow 12 (as shown in FIG. 1) may become a disadvantage in using the screeding device. Thus, workers or rakers may remove excess concrete or fill in concrete or "rake" the concrete (using suitable hand tools or the like) to the approximate elevation of the fingers. The fingers 113b provide a visible indicator which acts as a gauge for the workers to see how much concrete they need to  
30 remove or add to obtain the desired grade level in front of the screeding device 110.

Referring now to FIGS. 12-15, a wheeled screeding device 210 includes a screeding head 211, which includes a vibrator beam or member 220, attached to a framework 214. The framework 214 includes two pairs of spaced side frame members 214d which are connected together by a pair of generally parallel rods 215, similar to frame 14 discussed above. Rods

215 are also connected to a central frame portion 214b of framework 214, each side of which is further connected to a pair of generally parallel linkages 214e, 214f (in the illustrated embodiment, linkage 214f is generally parallel to and above linkage 214e at each side of the wheeled support 217). The spaced, parallel linkages 214e, 214f are connected to a rear end  
5 217a of a wheeled support 217, and are pivotable to adjust the framework 214, and thus the vibrating beam 220, relative to wheeled support 217, as discussed below.

Wheeled support 217 includes a pair of wheels 217b rotatably mounted at opposite ends of a laterally extending frame portion 217c. A handle 217d extends upward and forward from a forward end 217e of wheeled support 217 and may be grasped and pulled or pushed  
10 by an operator (shown moving the device in the direction of arrow A in FIG. 13) over and through the uncured concrete surface. The wheels 217b may be freely rotatable at each side of the wheeled support 217 or may each be powered or driven via a drive motor 217f to further enhance maneuverability and mobility of the screeding device 210. The drive motor or motors for the wheels may be independently operable and may be electric, hydraulic or  
15 any other means for rotatably driving the wheels, without affecting the scope of the present invention.

Vibrator beam 220 is mounted to framework 214 in a similar manner as discussed above with respect to screeding device 10, such that a detailed discussion will not be repeated herein. Likewise, screeding device 210 includes a powered vibrator device 231, with a power  
20 source (not shown) preferably mounted at wheeled support 217, for causing vibration of the vibrating beam 220, such as by rotatably driving a pair of counter rotating eccentrically weighted shafts or members (also not shown) at vibrating beam 220, as discussed above with respect to screeding device 10.

Although not shown in FIGS. 12-15, screeding head 211 of screeding device 210 may  
25 also include a plow or other grade setting device or member, such as a visual indicator, such as fingers or extensions along a tube, such as discussed above with respect to screeding device 110, or the like. The grade setting device may be adjustably mounted to the side frame members 214d and vertically adjustable relative to the vibrating beam 220, such as via a pair of elevation actuators (not shown), such as in a similar manner as discussed above with  
30 respect to screeding devices 10 and 110. Also, the elevation actuators may be operable in response to a laser plane detection system via a pair of laser receivers (also not shown) mounted to the vibrating beam.

The operating range height of the vibrating beam 220 may be manually adjusted relative to the level of the wheels 217b via an adjustment device 221 (FIGS. 12-14). This

adjustment is desirable to correspond to the thickness of the concrete slab where the vibrating beam 220 rests upon the uncured concrete and the wheels 217b may rest upon the sub-grade surface and drive through and/or over the uncured concrete. The adjustment device 221 may be an actuator, a threaded rod, turnbuckle, or any other extension and retraction device or the like, and is operable to adjust the height of the vibrating beam 220 relative to the wheeled support 217. As can be seen from FIGS. 12 and 13, extension and retraction of adjustment device 221 causes the frame 214 and vibrating beam 220 to lower and raise, respectively, relative to wheeled support 217 via pivotal movement of both sets of parallel linkages 214e, 214f simultaneously relative to rear end 217a of wheeled support and corresponding pivotal movement of central frame portion 214b relative to both sets of parallel linkages 214e, 214f. The movement of linkages 214e, 214f relative to wheeled support 217 and of frame portion 214b relative to linkages 214e, 214f provides generally vertical reciprocal movement of frame portion 214b relative to wheeled support 217, such that frame portion 214b remains in generally the same orientation as the frame portion 214b is raised or lowered relative to wheeled support 217.

Adjustment device 221 may be manually rotated or actuated to retract or extend and functions to raise and lower central frame portion 214b relative to wheeled support 217, while linkages 214e, 214f function to maintain the vibrating beam in its generally horizontal orientation or at its desired pitch during such vertical movement. The linkages 214e, 214f thus limit or substantially limit or preclude rotation of vibrating beam 220 about its longitudinal axis 220a (FIG. 12) as vibrating beam 220 is vertically adjusted to various operating range heights. Additionally, either or both of the linkages 214e, 214f may be replaced with adjustment devices that are operable to adjust the relative angle or pitch of the framework 214, central frame portion 214b, and vibrating beam 220 relative to both the wheeled support 217 and the generally horizontal work surface. The adjustment devices may be an actuator, a threaded rod, turnbuckle, or any other extension and retraction device or the like, without affecting the scope of the present invention, and are thus operable to adjust the "angle of attack" of the vibrating beam 220 relative to the wheeled support 217.

During use, an operator pulls, drives or otherwise moves wheeled screeding device 210 in the direction shown by directional arrow A in FIG. 13 to move wheels 217b along and through the uncured concrete surface and to move vibrating beam 220 and the plow over the uncured concrete surface to consolidate, smooth, level and/or flatten the surface at a desired grade. Vibrating beam 220 and any plow or other grade setting device as disclosed herein also move or cause sufficient concrete to fill in the tracks created by wheels 217b passing

through the uncured concrete ahead of vibrating beam 220. The operating range height of the vibrating beam 220 may be set relative to wheels 217b via adjustment device 221 and maintained at that level relative to the wheeled support. The desired grade elevation may also be adjusted by adjusting a plow (such as a plow of the types discussed above and shown in FIG. 1 and FIG. 10), or other grade setting device or member (not shown in Figs 12-15) relative to the vibrating beam 220 via elevation actuators or the like, such as discussed above with respect to screeding devices 10, 110 and shown in FIGS. 1, 10, respectively, while the screeding device is moved over and through the concrete surface.

Vibrating beam 220, and/or any other grade setting device, may at least be partially supported by a wheeled support 217 of the screeding device 210, and may include a wider or longer vibrating beam and plow than the non-wheeled screeding devices 10 and 110, as discussed above. For example, screeding device 210 may optionally include a vibrating beam 220 of approximately 6 feet (1.83 m), 7 feet (2.13 m), 8 feet (2.44 m), 10 feet (3.05 m), 12 feet (3.65m) or the like, in order to cover a desired amount of surface area with each working pass of the screeding device. The additional weight of larger members is thus at least partially supported by the wheels 217b. With the addition of a power source 30, electronic controls 21, and laser receivers 22 (as shown in FIG. 1 and FIG. 10), and wheel drive motors 217f, further advantages of screeding device 210 may be achieved, as will be described below.

Optionally, an upper portion of wheeled support 217 may be pivotally mounted to laterally extending frame portions 217c and wheels 217b such that the frame portion may be pivoted side to side, providing a roll action as needed through an axis 217j with respect to the direction of travel of screeding device 210. Such pivotal movement allows for adjustment of the plane of the vibrating beam 220 about longitudinal axis 217j of wheeled support 217.

Referring now to FIGS. 16-20, a powered wheeled screeding device 310 includes a screeding head 311, which includes a grade setting member or strike-off plow 312 and a vibrating beam 320, attached to a framework 314. Framework 314 is adjustably mounted to a wheeled support 317 and is adjustable to adjust a position or orientation of screeding head 311 relative to wheeled support 317. The wheeled support 317 includes a pair of powered drive wheels 317b and is movable or drivable over and/or through the uncured concrete.

Wheeled support 317 includes a pair of wheels 317b at opposite ends of a laterally extending frame portion 317c. A handle 317d extends upward and forward from a forward end 317e of wheeled support 317 and may be grasped and pulled or pushed by an operator to move and/or steer screeding device 310 over and through the uncured concrete surfaces or the

like. Preferably, each wheel 317b is powered or driven by its own drive motor 317f positioned at each wheel to further enhance maneuverability and mobility of the screeding device 310. In the illustrated embodiment, drive motors 317f are hydraulic motors powered by the power source 330 (which may include an engine, an hydraulic pump and a reservoir for hydraulic fluid or oil), which is operable to provide pressurized hydraulic fluid to the motors 317f and other hydraulically controlled cylinders and motors, as discussed below. However, drive motors 317f may be any other means for rotatably driving the wheels of the screeding device, such as electric, pneumatic, or the like, without affecting the scope of the present invention. Optionally, the drive means for the wheels may include a motor positioned above the central portion or axle 317w of the wheels 317b which is operable to drive the wheels via a chain drive mechanism and/or drive shafts (not shown), such that the drive means is positioned substantially above the axles of the wheels, thereby providing increased ground clearance for the wheeled support.

Additionally, power source or motor or engine 330 may be operable to actuate or energize an hydraulic motor 331a (FIGS. 16 and 21) of a vibration device 331, which is operable to cause vibration of the vibrating beam 320, in a similar manner as described above with respect to vibration device 31. In the illustrated embodiment, power source 330 is an internal combustion engine driving at least one hydraulic pump (for example, the power source may drive two hydraulic pumps 975a, 975b (as in a preferred embodiment, of which an hydraulic diagram 997 is shown in FIG. 28) or more hydraulic pumps, without affecting the scope of the present invention) and includes a fluid reservoir system 996 (FIG. 28) for providing pressurized fluid to actuators or hydraulic cylinders 318, 321 and hydraulic motors 331a, 317f of screeding device 310 via a plurality of solenoid valves and hydraulic controls 330b (FIGS. 16 and 17). Power source 330 is operable to drive or actuate the hydraulic motor 331a of vibration device 331 via hydraulic lines (not shown). In the illustrated embodiment, wheeled support 317 includes a pair of spaced plates 333 mounted at either end of cross member 317i for supporting the hydraulic valves and controls 330b. Optionally, the power source 330 may include an electric storage battery 330a, which may be positioned at the wheeled support 317, or within a battery mounting support 317g near handle 317d. Alternately, the power source 330 may include an electric drive motor, such as a battery-powered motor, a power-cord supplied motor, a compressed-air supplied pneumatic motor, or the like, without affecting the scope of the present invention.

In a preferred embodiment, screeding device 310 may also include controls for controlling the drive motors or drive means of the wheels through a range of selectable or

infinitely variable speeds as desired by the operator. For example, the controls may be manually actuated to drive the wheels in a forward direction or a reverse direction and may be actuated to drive the wheels independent from one another to assist in steering or turning the screeding device. Optionally, the controls may include a cruise control type control system which is operable to maintain a generally constant drive speed of the device as the screeding device moves over and through the uncured concrete.

Preferably, in a manner similar to vibration device 31 (FIG. 9) discussed above, vibration device 331 includes a pair of counter rotating eccentrically weighted shafts or members 332a, 332b (FIG. 21), which are rotatably driven by gears 332e at vibrating beam 320, as discussed above with respect to screeding device 10. Because vibration device 331 is substantially similar to vibration device 31 discussed above, a detailed discussion of vibration device 331 will not be repeated herein. Briefly, one of the eccentric weight members 332a may be rotatably driven by hydraulic motor 331a. The eccentric weight members 332a and 332b are engaged with one another via gear teeth 332e, such that rotation of member 332a causes a corresponding, opposite rotation of member 332b. As also discussed above, the vibrating beam 320 may be attached to the vibrating device 331 via cylindrical mounting members 340c, while the lower mounting plate 340b of vibrating device 331 is mounted to the framework 314 through one or more vibration isolator or elastic rubber sandwich mounts 314e (FIG. 17), which serves to help dampen the transmission of beam vibration to the support frame 314 and to the wheeled support 317 and operator handle 317d. The eccentric weight members 332a and 332b are preferably indexed relative to each other by means of the gear teeth 332e such that the vibration of the beam 320 is directed to act in a primary axis matching the elongated axis of the vibrator beam 320, while also serving to reduce, minimize, or cancel vibration in the horizontal axis perpendicular to the vibrator beam 320. The eccentric weight members thus allow the vibration displacement to be primarily directed in a desired plane, while substantially precluding vibration displacement in an undesired plane. Optionally, the speed of rotation of the eccentric weight members may be adjustable to a desired speed depending on the particular application of the screeding device and/or the length of the plow and/or beam mounted to the screeding device. Optionally, the mass of the eccentric weight members may be changed or adjusted through the addition or subtraction of weight from each eccentric weight member, or through replacement of the eccentric weights. As shown in FIGS. 16 and 22, vibrating device 331 is preferably substantially encased within a housing 331b to protect the eccentric weight members, gear teeth, and shaft bearings from the elements.

Similar to screeding head 11 of screeding device 10, discussed above, screeding head 311 of screeding device 310 includes grade setting member or strike-off plow 312, which is adjustably mounted to each of the side frame members 314d via a pair of parallel, plow adjusting linkages (not shown in FIGS. 16-20) and an elevation cylinder or actuator 318, in a manner similar to that discussed above in screeding device 10. The parallel linkages function to maintain horizontal attachment and generally parallel alignment of plow 312 relative to framework 314 as the plow is raised or lowered by actuators 318. The linkages thus limit or substantially preclude pivotal movement of the plow 312 as it is vertically adjusted by actuators 318. Preferably, elevation actuators 318 are operable to adjust the position of plow 312 relative to vibrating beam 320 in response to an on-site laser plane reference system and a laser receiver 322 positioned at a generally vertical rod or post 326 extending upwardly from plow 312 at or near each actuator 318, all as described above with respect to screeding devices 10 and/or 110.

Optionally, screeding head 311 may be detachably mounted to wheeled support 317, such that different length or different sized vibrating beams, plows, or strike-off devices, which may include various lengths of approximately 6 feet (1.83 m), 7 feet (2.13 m), 8 feet (2.44 m), 10 feet (3.05 m), 12 feet (3.65m) or the like, may be mounted to the wheeled support in order to cover a desired amount of surface area with each pass of the screeding device, depending on the particular application. Preferably, the screeding head 311 is easily detachable and mountable to wheeled support 317, such that the screeding head may be easily removed for transportation of the screeding device from one work site to another. In the illustrated embodiment, the wheeled support and wheels are preferably of such dimensions that the device may be moved or driven through a standard sized door opening, such as a 36 inch (91 cm) wide service door opening of a building, when the screeding head is temporarily removed from the wheeled support and manually carried through such a door opening by work personnel.

Optionally, the screeding head 311 may be adjustably mounted to wheeled support 317, such that the screeding head may be pivoted about a longitudinal axis 317j (FIGS. 17A, 17B and 19), which is generally parallel to the direction of travel of the screeding device, and/or about an axis 320b generally parallel to the longitudinal axis 320a of the vibrating beam (FIGS. 16 and 17). The screeding head 311 may thus be adjustable about one or more axes to a desired orientation with respect to the wheeled support. The screeding head may include a leveling system which functions to level the screeding head relative to the wheeled support or relative to a generally horizontal plane in response to an angle or level sensor. It is

further envisioned that the screeding head may be substantially fixed or locked in a desired orientation relative to the wheeled support to limit pivotal movement of the screeding head about one or both axes during operation of the screeding device, without affecting the scope of the present invention.

5 Framework 314 includes two pairs of spaced side frame members 314d which are connected together by a pair of generally parallel rods 315, similar to frames 14 and 214 discussed above. The rods 315 are also connected to a central frame portion 314b of framework 314, which is adjustably mounted to a rear end 317a of wheeled support 317 via a pair of linkages 323 and an adjustable member 325, such as a turnbuckle or the like.

10 Adjustable member 325 is mounted between a cross member 317i of wheeled support 317 and the central frame portion 314b of framework 314, and is adjustable to adjust a pitch or "angle of attack" of framework 314 and vibrating beam 320 relative to wheeled support 317. Similarly, adjustable member 325 and linkages 323 are pivotable relative to wheeled support 317 via hydraulic actuator 321, as best shown in FIG. 18, to adjust an operating range height  
15 of framework 314 and screeding head 311 relative to wheeled support 317. As described above with respect to adjustment device 221, adjustable member 325 functions to maintain vibrating beam 320 at the desired orientation or "angle of attack" relative to wheeled support 317 through the operating range of travel.

In the illustrated embodiment, central frame portion 314b is pivotally and adjustably  
20 mounted to rear end 317a of wheeled support 317 via the pair of parallel linkages 323, the adjustable member 325 and actuator 321. As best shown in FIGS. 16-18, central frame portion 314b includes a pair of upwardly extending brackets or flanges 319, which are bent or curved inwardly toward one another at their upper ends 319a to join one another. A cross member 319b extends between the upwardly extending brackets 319 and is fixedly secured to  
25 the brackets 319, such that pivotal movement of cross member 319b causes pivotal movement or rotation of the brackets 319 and of vibrating beam 320 and plow 312 about axis 320b defined by cross member 319b.

In the illustrated embodiment, cross member 319b includes an actuator mount 319c extending forwardly and upwardly from cross member 319b for mounting an end 321a of  
30 actuator 321, such as an hydraulic cylinder or other means for providing extension and retraction. Actuator 321 is positioned between actuator mount 319c and a second actuator mount 317h (FIG. 18) at rear end 317a of wheeled support 317. Also, each of the linkages 323 is pivotally mounted at one end to or at a respective end of cross member 319b and at the other end to or at the rear end 317a of wheeled support 317. Likewise, the adjustable



member 325 is mounted at one end to the upper end 319a of brackets 319 and at the other end to cross member 317i of wheeled support 317, and at a position generally above the mounting points for the linkages 323.

As can be seen in FIGS. 16-18, adjustment of the length of adjustable member 325 causes pivotal movement of brackets 319 and vibrating beam 320 and plow 312 about cross member 319b and pivot axis 320b. This adjusts the pitch or angle of the vibrating beam 320 relative to the uncured concrete surface. As can also be seen in FIGS. 16-18, extension and retraction of actuator 321 causes lowering and raising, respectively, of central frame portion 314b, along with vibrating beam 320 and plow 312, relative to the level of wheeled support 317. Accordingly, the pitch angle and general height of the vibrating beam 320 relative to the wheeled support 317 may be selected and adjusted via adjustment of the turnbuckle or adjustable member 325 and extension and/or retraction of the adjustable member 321. Once a desired pitch or angle is set via adjustment of adjustable member 325, the grade or elevation height of the vibrating beam may be adjusted via actuator 321, while the pitch angle or "angle of attack" of the vibrating beam remains at the desired setting. The vibrating beam 320 and plow 312 may be lifted or raised above the uncured concrete surface or any low obstacles to ease movement of the screeding apparatus 310 through a work site area to and/or from a desired location or area of the uncured concrete.

The pitch angle and operating range of the elevation height of the screeding head 311 are selected to provide optimal results based upon the site conditions, concrete slab thickness, and concrete mix design, to achieve the desired consolidation, leveling, and flattening and/or to affect the smoothing of the uncured concrete surface to fill in and smooth over the tracks left in the uncured and unscreeded concrete by the operator and the wheels 317b of the wheeled support 317 in front of the plow 312 and vibrating beam 320 as the screeding device 310 is pulled or driven in the direction of arrow A in FIG. 18 over and through the uncured concrete surface. Adjustment of the pitch of vibrating beam 320 may also adjust the axes of rotation of the eccentric members to adjust the vibration plane of the vibrating beam. Further adjustment within the operating range height of the plow 312 to adjust the amount of material being struck off in front of the vibrating beam 320 is provided by the elevation actuators 318 in response to the laser receivers 322 and the laser reference plane, as discussed above.

Optionally, screeding apparatus 310 may include a pair of wheel track fillers (not shown in FIGS. 16-20, but such as shown in FIG. 23), which are operable to deflect or direct concrete into the furrows or channels formed by the wheels as the screeding device is moved through the uncured concrete. The wheel track fillers may be angled plow type devices

which are positioned in front of a forward side of the plow, and just rearward of the wheels, to push or deflect concrete toward or into the furrows to generally fill in the furrows before the plow engages the uncured concrete. Optionally, screeding apparatus 310 may include one or more work lights 360 (FIG. 16), which provide illumination of the work site during  
5 darkened conditions.

Referring now in detail to FIGS. 17A and 17B, apparatus 310 maintains a center of gravity located in close proximity to and to the rearward side of the wheels 317b and axis 317w according to the direction of travel. The location of the center of gravity relative to the wheels 317b results in the screeding device 310 having the characteristic of being nearly  
10 balanced about an axis near and parallel to rotation axis 317w at the wheels 317b, with a greater portion of the apparatus' weight resting upon the wheels and a lesser portion of the apparatus' weight resting upon the vibrating beam 320, such that vibrating beam 320 is at least partially supported by, or essentially "floating" upon, the uncured concrete surface, and applies a sufficient and desired amount of down-pressure to work the surface. The amount of  
15 weight or downward force applied by vibrating beam 320 may be adjustable via the fore-aft adjustment of detachable counter weights (not shown) fastened to appropriate locations on the screeding device 310. Optionally, the amount of weight or downward force applied by vibrating beam 320 may be adjustable via an adjustable mounting location or mechanical adjustment slots or the like (not shown) between the laterally extending frame portion 317c  
20 and the wheeled support members 317a.

Optionally, and preferably, and as shown in FIGS. 17A and 17B, screeding device 310 may include an adjustment device 317k, which functions to adjust the fore-aft position of a lower wheeled support sub-frame assembly 317m, which is generally comprised of the laterally extending frame portions 317c, drive motors 317f, and wheels 317b, relative to an  
25 upper wheeled support sub-frame assembly 317n, which is generally comprised of handle 317d, forward end of wheeled support 317e, and rear end of wheeled support 317a. Lower wheeled support sub-frame assembly 317m is able to slide relative to upper sub-frame assembly 317n along longitudinal shaft 317q via bearings 317r. Longitudinal shaft 317q is mounted at its opposite ends between a front cross support 317p and a rear cross support  
30 317o of upper sub-frame assembly 317n, thereby securing it to upper wheeled support frame 317n. The sliding axis of the lower wheeled support sub-frame assembly 317m relative to upper sub-frame assembly 317n is thus generally coaxial with the longitudinal axis of pivotal motion 317j, which is parallel to the direction of travel of the screeding device 310. A center actuator bracket 317s and a rear actuator bracket 317t contain a center u-joint 317u and a rear

u-joint 317v, respectively, for pivotally mounting an actuator or adjustment device 317k therebetween. Therefore, center u-joint 317u and rear u-joint 317v are each able to maintain at least two axes or degrees of motion freedom to preclude binding of adjustment device 317k when lower wheeled support sub-frame assembly 317m is pivoted relative to upper wheeled support sub-frame assembly 317n. Relatively small degrees of twisting action along the axis of the actuator itself may be taken up by the actuator.

As shown in this example, the adjustment device 317k is a 12-volt DC linear electric actuator available commercially and manufactured by Warner Electric of South Beloit, Ill., USA. Other means of adjustment devices may also or otherwise be used, such as, but not limited to, a mechanical turnbuckle, a threaded shaft with a hand-wheel adjustment, a pressurized hydraulic cylinder, or a toothed rack and pinion gear, or any other actuators or the like that may be incorporated into the design to perform a similar adjustment function either manually, or as an option automatically, as may be desired, without affecting the scope of the present invention. In similar fashion, the center u-joint 317u and rear u-joint 317v of actuator 317k may also be replaced by spherical bearings, ball joints, elastic mountings, or the like, in order to accomplish equivalent degrees of mechanical freedom to limit or substantially preclude mechanical binding or limitation of adjustment device 317k, without affecting the scope of the present invention.

As can be seen in FIGS. 17A and 17B, shifting the lower wheeled support sub-frame portion 317m and wheels 317b to the front with respect to the upper wheeled support frame sub-frame 317n will increase the proportion of weight on the rearward side of the screeding apparatus 310 and the screeding head 311, which results in an increase in the force or down pressure exerted upon the uncured concrete by the vibrating beam 320, which is also supported by and works the uncured concrete surface. Conversely, shifting the lower wheeled support sub-frame portion 317m and wheels 317b to the rear with respect to the upper wheeled support frame sub-frame 317n will decrease the proportion of weight on the rearward side of the screeding apparatus 310 and the screeding head 311, which results in a decrease in force or down pressure exerted upon the uncured concrete by the vibrating beam 320, which is also supported by and works the uncured concrete surface. Thus, the means described above serves to adjust the force or "degree of float" of the vibrating beam 320 upon the uncured concrete surface as the uncured concrete surface is being worked and smoothed to the desired final elevation.

Additionally, the above described adjustment means may further include means to automatically control the position of the lower wheeled support sub-frame portion 317m and

wheels 317b relative to the upper sub-frame 317n via an electric actuator 317k in response to measurements taken by a force sensor (not shown) mounted at the vibrating beam 320 of the screed head 311. The force sensor may measure the force exerted by the vibrating beam 320 against the concrete surface and accordingly output an electrical input signal to the onboard  
5 electronic control box (not shown), where an appropriate output signal is then generated by the control box to operate the electric actuator 317k and thus to shift the lower wheeled support sub-frame portion 317m relative to upper sub-frame assembly 317n accordingly and in the proper direction, in order to automatically maintain an approximate range of desired and preset "degree of float" of the vibrating beam 320 on the uncured concrete surface. The  
10 control system of screeding device 310 thus may provide an automatic closed-loop "degree of float" control system for the screeding device 310.

Alternately, it is further envisioned that the screeding head may be mounted at a rearward end of an extendable or adjustable boom (not shown) which extends rearward from the wheeled support. Extension of the boom then moves the screeding head 311 further  
15 rearward to increase the force of the screeding head 311 on the uncured concrete surface by increasing the amount of the unsupported weight of the screeding head 311 and the extendable boom. Conversely, retraction of the boom then moves the screeding head 311 further forward or closer to the wheels 317b to decrease the force of the screeding head 311 on the uncured concrete surface by decreasing the amount of the unsupported weight of the  
20 screeding head 311 and the extendable boom as they are increasingly supported by the wheels 317b. Alternately, the weight or down pressure exerted by the beam on the uncured concrete surface may be adjusted via weights (not shown) which may be added or removed from one of the ends of the screeding apparatus to affect the balance of the unit, without affecting the scope of the present invention.

25 Lower wheeled support sub-frame portion 317m, including laterally extending frame portions 317c, may be pivotally mounted to upper wheeled support sub-frame 317n, such that the wheeled support 317 may be pivoted or tilted side to side. This provides a roll action through axis 317j with respect to the direction of travel of the wheeled support 317. Such free pivotal movement allows for adjustment of the plane of the vibrating beam 320 about a  
30 longitudinal axis 317j of wheeled support 317. In such applications, it is a further option that the screeding apparatus may include oil-filled oscillation cylinders or dampers (such as discussed below and as shown in FIGS. 23 and 23A) or the like to control and dampen such side to side pivotal movement of the screed head 311. This allows controlled axial movement of the screed head 311 along and/or about pivot axis 317j and also serves to enhance and

maintain the stability of the apparatus while the screeding device 310 advances along a work path or is traveling along to and from a work site over rough terrain. The oscillation dampers may be oil-filled cylinders or gas-spring shock absorbers, but may alternately be any other form of dampening device, such as friction or other shock absorbing type devices or the like, without affecting the scope of the present invention.

Screeding apparatus 310 may also include a temporary mechanical link or hydraulic locking mechanism to temporarily fix or lock the lower wheeled support sub-frame portion 317m, including the laterally extending frame portion 317c, at a desired angle or orientation with respect to the wheels 317b. Alternately, the mechanical links may be replaced with oil-filled shock absorbers or hydraulic cylinders connected hydraulically to one another such that the free flow of fluid, and therefore pivotal motion at axis 317j, can be readily controlled through actuation of a fluid or selector valve 990a and/or the selected sizing of the orifices within check valves, such as orifices 990b and 990c as shown in FIG. 28 and as discussed below. Actuation of the selector valve may be either mechanical or through an electrical switch or electronic device (not shown) serving to control the electromechanical hydraulic solenoid valve or selector valve. The screeding device control system thus may provide an “oscillation lock” control system for the screeding apparatus or device 310.

It is further envisioned that such a screeding apparatus “oscillation lock” control system may include an angle or tilt sensor (not shown) to automatically detect the angle of tilt of the frame portion relative to the frame or the wheels or relative to a horizontal plane. In such an application, the screeding apparatus may be further operable to automatically sense the screed head position and to adjust the frame portion to a generally level or generally horizontal orientation (or to a desired angle) in response to the angle sensor, such as via a motor, hydraulic cylinder, or electric actuator (also not shown) operable to pivot frame portion 317c about axis 317j to a desired angle relative to wheels 317b.

Referring now to FIG. 23, a powered wheeled screeding device 410 includes a screeding head 411, which includes a grade setting device, such as a plow 412, and a vibrating beam 420 attached to a framework 414, similar to screeding device 310 discussed above. Screeding head 411 also includes a concrete moving device 413, which is operable to engage and move excess uncured concrete from in front of the vibrating beam 420 and/or plow 412, such as an auger mounted to the plow 412 at laterally opposite ends thereof. Screeding device 410, vibrating beam 420 and plow 412 are otherwise substantially similar to screeding device 310, vibrating beam 320 and plow 312, discussed above, such that a detailed discussion will not be repeated herein.

Concrete moving device or auger 413 is rotatably mounted between a pair of mounting brackets 412a extending forwardly from each end of plow 412, such that auger 413 extends generally along and generally parallel to the entire length of plow 412. Auger 413 is mounted along the front portion or edge of the plow 412 and is rotatable to engage and  
5 remove excess concrete that may accumulate in front of screeding device 410 as the machine progresses through the uncured concrete. Auger 413 comprises a generally cylindrical tube portion 413a and a helical or spiraling, generally continuous, ridge, blade or flighting 413b extending radially outwardly from tube portion 413a, such that as auger 413 is rotated, blade or flighting 413b scrapes excess concrete from the uncured concrete surface and moves the  
10 excess concrete toward one side or the other, or just ahead of screeding head 411, depending on the direction of rotation of auger 413. Auger 413 is positioned relative to plow 412 such that a lower edge of flighting 413a is just above a lower edge of plow 412, such that auger 413 removes excess concrete, or respectively carries and adds concrete to fill any low spots while plow 412 sets the uncured concrete surface to the desired grade. Alternately, the auger  
15 413 may be positioned relative to the plow 412 such that a lower edge of flighting 413a is equal in elevation to the lower edge of the plow 412, such that the auger 413 removes any excess concrete or respectively carries and adds concrete to fill any low spots and therefore sets the uncured concrete surface to the desired grade.

Auger 413 is driven by a driving mechanism or motor 413c which may turn or rotate  
20 the auger in either direction, such as in response to control by the operator. The driving mechanism may be a hydraulic motor positioned at one end of the auger and operable to rotate the auger via a keyed-shaft or the like. Alternately, other means to drive the auger may be used, including but not limited to, electric or air drive motors, roller chains and sprocket gears, right-angle gearboxes, and/or cogged belts and pulleys and/or the like, without  
25 affecting the scope of the present invention. Optionally, a "center drive position" may be implemented with a drive chain engaging a sprocket mounted near the mid-point of the auger, without affecting the scope of the present invention. If such a drive chain or belt were implemented, the chain or belt may preferably be substantially or completely enclosed to limit or preclude exposure to the concrete aggregate, in order to avoid potential jamming of  
30 the drive chain or belt.

Preferably, the auger 413 is constructed of lightweight plastic in order to minimize the weight of screeding device 410. Optionally, the auger 413 may comprise injection-molded modular plastic auger sections with an interlocking lap joint that allows the sections to align with respect to one another when they are joined together along a common center drive shaft.

Such an auger assembly is commercially available from The Lundell Corporation, of Odebolt, Iowa, USA, and is used in a variety of applications including farming, foods, and material handling equipment. Since the auger on screeding device 410 is preferably a lightweight plastic member, the auger may not be required or suitable to cut or establish the final grade height of the concrete. Therefore, the dimensional accuracy of the auger flighting or any deflection in the auger main shaft at its center due to material loads may not be as critical as with other screeding machines. The auger 413 on screeding device 410 functions to remove excess material off to the side such that plow 412 will continue to cut the grade, in a similar manner as screeding device 310, as discussed above.

It is envisioned that the screeding device of the present invention may alternately include an auger or the like positioned along a forward edge of the vibrating beam, whereby the auger is operable to cut or establish the grade height of the concrete as the screeding device is moved along and through the uncured concrete. Such an embodiment may or may not include a strike-off plow or indicating member. The auger may replace the function of this component entirely or, optionally, the auger may supplement engagement and strike-off of the concrete. The auger or other such device may be vertically adjustable in response to the elevation actuators or cylinders to adjust the concrete surface to the desired grade, such as in a manner similar to the other grade setting devices 12, 112, 212, 312 and/or 412, discussed above. In such an embodiment, it is further envisioned that the auger may be constructed to close tolerance dimensions and constructed of materials of increased structural rigidity, such as alloy steel or carbon fiber or the like, such that the auger may be increasingly suited for cutting or establishing the grade height of the uncured concrete as the screeding device is moved along and through the uncured concrete.

Screeding device 410 preferably includes a pair of laser receivers 422 mounted to the ends of respective rods 426 extending upward from the plow 412, similar to laser receivers 22, discussed above. Preferably, the laser receivers 422 are positioned generally near to the elevation actuators 418 at the frame members 414d, such as discussed above with respect to screeding device 110. The grade of the uncured concrete surface may thus be set by grade setting device or plow 412 in response to a laser plane generating system and an established laser plane reference, as discussed above. It is further envisioned that the elevation actuators 418 may be at least occasionally correspondingly operable in response to a signal from only one of the laser receivers 422, such as in situations where the laser beam reference plane may be temporarily blocked from being received, such as disclosed in U.S. Pat. No. 5,556,226,

issued Sep. 17, 1996 to Hohmann, Jr. and entitled AUTOMATED, LASER ALIGNED LEVELING APPARATUS, which is hereby incorporated herein by reference.

Optionally, the elevation actuators may be controlled by other means or control systems, such as shown in FIG. 23A, such as a three dimensional profiler system (such as a 3-D Profiler System commercially available from Somero Enterprises), such as disclosed in U.S. Pat. No. 6,227,761, issued May 8, 2001 to Kieranen et al. and entitled APPARATUS AND METHOD FOR THREE DIMENSIONAL CONTOURING, which is hereby incorporated herein by reference. Optionally, screeding apparatus 410 may also include at least one sonic tracer or sensor 455 and at least one three-dimensional laser tracking target 460 (as shown in FIG. 23A and as disclosed in U.S. Pat. No. 6,227,761). The sonic tracer or sensor 455 may be adjustably mounted or secured at the ends of the screeding head 411, whereby at one end of the screeding head the sonic sensor 445 is operable to detect the relative elevation or height of a previously screeded surface using the sonic sensor for measuring a surface screeded during an earlier pass of the screeding apparatus) to assist in blending adjacent portions of the uncured concrete surface, while at the opposite end of the screeding head the tracking target 460 is operable to measure the location of the screeding head 411 in three-dimensions including elevation of the screed head 411. The screeding apparatus 410 may then be operable to adjust the elevation actuator 418 at one end of the plow, auger 413, or grade setting device, and thus of the vibrating beam 420, in response to a signal from the sonic tracer or sensor 455, while at the opposite end of the screed head 411, screeding apparatus 410 may be operable to adjust the other elevation actuator 418 at the opposite end of the plow, auger 413, or grade setting device, and thus of the vibrating beam 420, in response to a signal from the three-dimensional tracking target 460 and computer controlled 3-D system.

Alternately, and with reference to the screeding device shown in FIG. 24, a screeding device 510 of the present invention may include other grade setting or mechanical devices or which may be operable to accomplish the same or similar task as the auger 413, discussed above. Screeding device 510 may include a screeding head 511 having a vibrating beam or member 520 and a grade setting device 512 attached to a framework 514. Grade setting device 512 includes a continuous flexible belt 513 which is routed around a pair of guides or rollers 513b mounted at laterally opposite sides of the screeding device 510. The belt 513 preferably includes a plurality of paddles 513a extending outwardly from the belt 513 for engaging and moving the excess uncured concrete as the belt is moved about rollers 513b.



In the illustrated embodiment, belt 513 and paddles 513a function to cut and establish the grade of the uncured concrete surface as screeding device 510 is moved along and through the uncured concrete. Grade setting device 512 further includes a center support structure 512a extending along the grade setting device to support belt 513 and limit deflection of belt 513 as the belt engages the excess uncured concrete.

Belt 513 may be driven in either direction around rollers 513b via a rotatable drive or power source 513c, which is operable to rotatably drive one of the rollers 513b in either direction to move the belt and paddles around rollers 513b to move the excess uncured concrete to either side of the screeding device. The power source 511 may comprise a hydraulic motor or any other means for causing rotation of one of the rollers 513b to move the belt 513 around both rollers 513b.

Screeding device 510 is otherwise substantially similar to screeding devices 310 and 410, discussed above, such that a detailed discussion will not be repeated herein. Screeding device 510 preferably includes a pair of laser receivers 522 mounted to the upper ends of respective rods 526 extending upward from grade setting device 512, similar to laser receivers 22, discussed above. Therefore, the grade of the uncured concrete may be set by belt 513 of grade setting device 512 in response to a laser plane generating system and an established laser plane reference, as discussed above. A pair of actuators 518 and linkages 516 may function to generally vertically adjust the position of grade setting device 512 relative to frame members 514d of framework 514 and, thus, relative to vibrating beam 520, in response to the laser plane system, similar to the actuators 12 and linkages 16 of screeding device 10, discussed above.

Optionally, in place of the continuous, flexible belt as shown in FIG. 24, a roller chain riding on and between a pair of sprockets (not shown) may be implemented with the screeding device of the present invention. The chain may further include multiple paddles extending outward from the chain to engage and move the excess uncured concrete.

Optionally, in place of the continuous, flexible belt as previously shown in FIG. 24 and described above, a wheeled screeding device 610 may include a screed head 611, which includes a vibratory beam or member 620 and a horizontal spinning tube 613 (FIG. 25). The spinning tube 613 has an axis of rotation parallel to the elongated vibrating member 620 and includes a bracket or frame member 612 for mounting the ends of the spinning tube to the frame members 614d of framework 614 via linkages 616. The working surface of the spinning tube 613 may be either smooth or contoured to include small working edges or paddles (not shown) to aid in striking-off and moving excess concrete in the direction of

travel of the screeding device 610. The spinning tube 613 may be spun or rotated via an hydraulic motor 613b mounted at one end of spinning tube 613. The elevation of the spinning tube 613 may be adjusted relative to the framework 614 of screed head 611 via linkages 616 and actuators 618, in a similar manner as described above. Preferably, the actuators 618 are operable in response to laser receivers 622 mounted to a support or bracket 612 of spinning tube 613 via masts or rods 626.

Other means for engaging and moving excess concrete to a side or ahead of the screeding device may otherwise be implemented on the screeding device on or along the forward edge of the vibrating beam or on or along the forward edge of the plow or the like, without affecting the scope of the present invention.

With reference to FIG. 26, a screeding device 710 includes a wheeled support 717, which includes a single wheel 717b for guiding and moving the screeding device over and through the uncured concrete surface. Screeding device 710 further includes a screed head 711 mounted at a rearward end 717a of wheeled support 717, such as in a similar fashion as described above with respect to the screed heads 311, 411, 511, 611 of the various screeding devices shown and described herein. Wheeled support 717 also includes a power source 730, which may include an engine, an hydraulic pump, and a reservoir for hydraulic fluid or oil, which is operable to provide pressurized hydraulic fluid or otherwise drive a single drive motor (not shown) to drive the wheel 717b. A handle 717d is provided at a forward end 717e of wheeled support 717 for an operator to guide and/or pull or push the screeding device 710 as it travels over and through the uncured concrete.

Similar to the embodiments discussed above, vibrating beam 720 of screeding device 710 is mounted to a framework 714 and extends laterally outwardly from a pair of frame members 714d of framework 714. Grade setting device 712 is adjustably mounted to the framework via linkages 716 and is preferably adjusted via actuation of actuators 718, which, in turn, are preferably actuated in response to laser receivers 722 (mounted on grade setting device 712 via masts or rods 726) receiving a laser reference plane (not shown), as described above.

Screeding device 710 is preferably approximately balanced in a similar fashion to the previously described two-wheel screeding device 310 having a pivot axis 317j as shown in FIGS. 17A-20. Stability of the apparatus is made through contact and engagement of the screed head 711 with the uncured concrete surface, with a desired and adjustable proportion of the weight of the device supported by surface contact of the vibrating member 720 with the surface of the uncured concrete. Screeding device 710, screed head 711, vibrating beam 720

and grade setting device 712, which may optionally comprise one or more various devices of the types discussed above, such as a spinning roller (as shown in FIG. 25), a flexible belt and paddles (as shown in FIG. 24), an auger (as shown in FIGS. 23 and 23A), and/or a plow or the like, are otherwise substantially similar to the elements found in the screeding devices 5 610, 510, 410, 310, discussed above, such that a detailed discussion will not be repeated herein.

Referring now to FIG. 27, another screeding device 810 in accordance with the present invention is shown. Screeding device 810 is configured to be able to exhibit the various functions and elements of the present invention (either separately or in combination) 10 as described herein with respect to the other embodiments, such that a detailed discussion of screeding device 810 will not be repeated herein. Suffice it to say that screeding device 810 includes a screeding head 811 mounted at a rearward end 817a of a wheeled support 817. Wheeled support 817 includes a pair of wheels 817b rotatably mounted at opposite ends of a laterally extending frame portion 817c. Wheeled support 817 at least partially supports the 15 power source (not shown in FIG. 27) and generally contains the power source and other components of the wheeled support within a housing 830 of wheeled support 817.

Screeding head 811 includes a grade setting or indicating device, such as a strike-off plow 812, and a vibratory beam or member 820. Vibratory beam 820 is mounted to framework 814 and extends laterally outwardly in opposite directions from a pair of frame 20 members 814d of framework 814. Vibratory beam 820 may be any type of vibratable member and preferably has a generally planar, flat and smooth lower surface for engaging and working the uncured concrete surface.

Plow 812 is attached to framework 814 by two small sets of linkages 816 and is vertically adjustable relative to the framework 814 by a pair of elevation actuators 818. Plow 25 812 includes angled end portions or wings 812a at each end thereof. The angled end portions 812a are angled forwardly at the ends of the plow and function to keep the excess concrete at the forward edge of the plow and, thus, to reduce the amount of concrete that may slide off of the ends of the plow during operation and movement of screeding device 810 over and through the uncured concrete. As described above with respect to other screeding devices of 30 the present invention, the elevation of plow 812 relative to framework 814 may be adjustable by actuators 818 in response to input signals from each of a pair of laser receivers 822, which each sense the elevation of a fixed laser plane reference (not shown in FIG. 27) that has been established over the job site by a separate rotating, laser plane generator or projector (also not

..  
..  
shown). Each laser receiver 822 is mounted to a support rod or mast 826 which is in turn mounted to the grade setting device or strike-off plow 812.

Similar to the embodiments discussed above, screeding device 810 is at least partially supported on an uncured concrete surface and moved along and over the concrete surface to  
5 screed and smooth the surface via vibration of the vibrator beam 820 as the vibrator beam 820 floats on or is at least partially supported on the uncured surface. The plow 812 is adjustable with respect to the vibrator beam 820 to adjust a level or grade of the uncured concrete to a desired grade as screeding device 810 is moved along and over the uncured concrete. The other details of screeding device 810 may be substantially similar to various  
10 aspects of screeding device 10, 110, 210, 310, 410, 510, 610 and/or 710, discussed above, such that a detailed discussion of those aspects will not be repeated herein.

With reference to FIG. 28, an hydraulic diagram or schematic 997 is shown which is generally representative of an hydraulic system for the screeding devices shown and described herein and particularly for the embodiment shown in FIG. 27. With the screeding  
15 device in operation, hydraulic oil or fluid is drawn up from a reservoir 996 through a strainer 970a by pumps 970b and 975a as they are mechanically driven by a power unit or source 930. Pressurized hydraulic fluid is thus made available for the functioning of a wheel drive or propulsion hydraulic circuit 970. Fluid passes through a variable flow control 970c and a pressure-compensated flow control valve 970e while any excess pressure, and thus fluid, may  
20 be diverted back to reservoir 996 by a relief valve 970d. Hydraulic fluid passing through a selector valve 970f may be controlled through actuation of the selector valve 970f to select forward or reverse travel direction of the screeding apparatus 810 (FIG. 27) by changing the respective directions of rotation of wheel drive motors 917f. A pair of counter balance valves 970g and 970h serve to control the flow of hydraulic fluid under variable load conditions  
25 such as encountered by inclines, working loads, or the like. A variable flow control valve 970i, a flow divider-combiner valve 970j, and a selector control valve 970k serve to control the flow into and out of the wheel drive motors 917f, such that differential or non-differential drive action of the wheels 817b (FIG. 27) may be selected via actuation of the selector valve 970k as desired by the operator to enhance either turning of the apparatus 810 or driving  
30 effort made by the wheels 817b under operating load. Thus, in this example, control of selector valve 970k provides a “differential lock” control of propulsion hydraulic circuit 970.

With the screeding device in operation, hydraulic oil or fluid is drawn up from reservoir 996 through strainer 970a by pumps 970b and 975a as they are mechanically driven by power unit 930. Pressurized hydraulic fluid is thus made available for the functioning of

an auger or belt hydraulic circuit 975. Hydraulic circuit 975 is optionally included in this example to drive an hydraulic motor 913c which in turn drives an auger (such as auger 413 shown in FIG. 23A) or, as a further option, a belt (such as belt 513 shown in FIG. 24) or the like. Pressurized hydraulic fluid flows from pump 975a through a pressure-compensated flow control valve 975b and through a selector valve 975c to a motor 913c. Selector valve 975c may be actuated by the operator to drive the motor of the auger or belt in a forward or reverse direction, and also provides a stopped function. Any excess hydraulic pressure and fluid may also be diverted back to reservoir 996.

A portion of the excess hydraulic pressure and flow is automatically diverted to a vibrator motor hydraulic circuit 980. Also, any excess hydraulic pressure and fluid may be diverted by a relief valve 980a back to reservoir 996. Pressurized hydraulic fluid flows from pressure-compensated flow control valve 975b and/or selector valve 975c through a pressure-compensated flow control valve 980b and through a selector valve 980c to a vibrator motor 931a, and then returns to reservoir 996. Selector valve 980c may be actuated by the operator to turn the vibrator motor 931a on or off. A check valve 980d serves to preclude possible damage to vibrator motor 931a where fluid supply from selector valve 980c is suddenly interrupted and inertial forces within the vibrator motor 931a and rotating mechanical elements must be dissipated. Check valve 980d allows hydraulic fluid to flow freely to vibrator motor 931a momentarily until vibrator motor 931a comes to a stop. Thus, in this example, hydraulic circuit 980 and the related components as described above provide vibration to a screed head, such as screed head 811 of apparatus 810 (FIG. 27).

For actuation of the lift cylinder 921, pressurized hydraulic fluid flows from pressure-compensated flow control valve 980b and/or selector valve 980c to supply a hydraulic cylinder circuit 985. Pressurized hydraulic fluid passes through a pressure-compensated flow control valve 985b, a selector valve 985c, and a relief valve 985d to operate lift cylinder 921. Selector valve 985c may be actuated by the operator to extend and retract hydraulic lift cylinder 921 (such as lift cylinder 321 as shown in FIGS. 18-20) to either raise or lower the screeding head (such as screeding head 311) as desired. Relief valve 985d limits the maximum pressure and therefore the maximum force available to the rod-end of lift cylinder 921. Excess pressure and hydraulic fluid from hydraulic circuit 985 may be diverted back to reservoir 996 by pressure-compensated flow control valve 985b as well as selector valve 985c. Thus, in this example, hydraulic circuit 985 and the related components as described provide a raise and lower or screed head lift function for the screeding apparatus of the present invention.

Residual hydraulic fluid pressure and flow from hydraulic circuits 975, 980, 985 serves to enable the function of the oscillation lock hydraulic circuit 990. Hydraulic fluid passes through a selector valve 990a, check valves with orifices 990b and 990c, and into a pair of oscillation lock cylinders 935. Whereas oscillation lock cylinders 935 (and cylinders 435 in FIG. 23) serve to control the pivoting or side to side roll action of a wheeled support, such as described previously with respect to wheeled support 317, about a pivot axis (such as pivot axis 317j), the operator may actuate selector valve 990a to respectively stop fluid flow between oscillation cylinders 935 or may allow a controlled fluid flow between oscillation cylinders 935 through check valves with orifices 990b and 990c. Thus, in this example, hydraulic circuit 990 and the related components as described provide a useful oscillation lock function for the screeding apparatus of the present invention.

The majority of hydraulic fluid returning to reservoir 996 from the above described hydraulic circuits may pass through a cooler 995 and a filter-diffuser 995b, as shown in hydraulic circuit 997 of FIG. 28. A cooler by-pass valve 995a may optionally be included in this example to provide an alternate path for hydraulic fluid to pass around the cooler 995, as may be necessary in the event of cold ambient working temperatures.

It may be understood that actuation of the above described selector valves may be accomplished and implemented through various means or options, such as, but not limited to, manual input or control by the operator, mechanical control through a machine linkage or like elements, electrical control by an electro-mechanical actuator, hydraulic control, or otherwise electronically controlled, without affecting the scope of this invention.

Although the screeding devices of the present invention are shown as having a vibrating beam or member for working or smoothing, compacting and/or consolidating the uncured concrete surface, other forms of concrete surface working devices or members or elements may be implemented, without affecting the scope of the present invention. For example, and with reference to FIGS. 29A-C, a concrete working or leveling or raking device 1010 may comprise a concrete surface working member or flotation roller 1020 and a grade setting member or plow or rake 1012 adjustably mounted at a forward side of roller 1020. Roller 1020 is supported on the uncured concrete and rolls over the uncured concrete surface in a first direction of travel indicated by arrow A in Fig. 29B, while rake 1012 may be adjusted relative to roller 1020 via an actuator 1018, as discussed below, to adjust the depth of cut of the rake or grade setting device 1012 to keep the flotation roller 1020 at the proper grade. Actuator 1018 may preferably be an electric linear actuator or the like, without affecting the scope of the present invention.

Concrete raking device 1010 includes a framework 1014, which further includes a handle portion 1014a extending from a generally central portion of rake 1012 for a user or raker to grasp and pull or guide raking device 1010 over and along the uncured concrete surface. Framework 1014 includes a pivot bar or connecting member 1014b which extends  
5 generally perpendicular to the direction of travel along and above rake 1012 and is pivotally connected to the opposite ends of rake 1012 creating a horizontal pivot axis 1014h. A pair of side frame members 1014c are rigidly or fixedly mounted at one end to the opposite ends of pivot bar 1014b and pivotally mounted at the other end to a central axle 1020a of roller 1020. Pivotal movement of pivot bar 1014b thus causes arcuate movement of roller 1020 relative to  
10 pivot bar 1014b, while roller 1020 may rotate or roll about its axis 1020a. Such arcuate movement of roller 1020 via pivotal movement of pivot bar 1014b results in a vertical adjustment of roller 1020 relative to rake 1012, as discussed below.

Pivot bar 1014b includes an actuator mounting bracket or lever 1014d extending upwardly from the central portion of pivot bar 1014b for pivotally mounting one end of  
15 actuator 1018 thereto. The other end of actuator 1018 is mounted to handle portion 1014, as best shown in FIGS. 29A and 29B. Actuation or extension/retraction of actuator 1018 causes pivotal movement or rotation of pivot bar 1014b via lever arm 1014d. Because pivot bar 1014b is pivotally mounted to rake 1012 and fixedly mounted to side frame members 1014c, pivotal movement of bar 1014b causes raising or lowering of flotation roller 1020 relative to  
20 rake 1012, which further causes rake 1012 to establish a lower grade or higher grade, respectively, relative to a fixed reference, such as a laser plane or the like. This allows an operator of raking device 1010 to allow the rake 1012 to rest partially upon the uncured concrete, since the roller 1020 will support the rake at the desired grade while the roller is supported on the concrete surface. The uncured concrete thus serves as an elevation or grade  
25 height reference for the screeding or raking device 1010.

Preferably, raking device 1010 includes a laser receiver 1022 mounted on a mast or rod 1026 extending upward from a pair of frame members 1014e extending from the ends of rake 1012 and a third frame member 1014f extending upward from handle portion 1014a. A fourth frame member 1014g may be added as shown in FIG. 29A to enhance the rigidity and  
30 stability of frame members 1014e and thus of mast 1026. Actuator 1018 is operable to automatically raise and lower roller 1020 relative to rake 1012 in response to a signal from laser receiver 1022 via an electronic controller (not shown).

Therefore, raking device 1010 provides an automatic control system using a laser receiver and a flotation roller that partially supports the raking device 1010 on an uncured

concrete surface which also serves as an elevation reference. During operation, as the raking device is manually drawn towards the user or raker via pulling on handle portion 1014a in the direction indicated by arrow A in Figure 29B, laser receiver 1022 monitors the elevation of the cutting edge of rake 1012 and adjusts actuator 1018 and thus the level of flotation roller 1020 to keep the cutting edge at the desired grade. If the grade of the placed concrete is too high (such as one or two inches (25mm to 50mm) above the desired grade), the laser receiver will cause the roller 1020 to raise to a corresponding height above the raking edge 1012, thus automatically lowering the grade setting member 1012 a desired amount. Additionally, a maximum height correction of the roller may be adjusted to control the maximum depth of cut per stroke that the rake 1012 may engage the concrete as it travels in direction A so as to maintain the raking device within the physical effort capabilities of the raker. In areas where excess material is present, each successive stroke may additionally remove more excess concrete from a given location until the desired grade height has been reached. When the draw stroke is completed in direction A, the raker need only push the raking device back outward over the uncured concrete in the opposite direction without lifting the raking device for another stroke, since as soon as the raking device is pushed by the raker, a rotation sensor or direction switch (not shown) attached to the flotation roller may serve to automatically lower the flotation roller 1020 and raise the grade setting device 1012, so that the raking device will roll easily over the concrete surface opposite the direction indicated by arrow A.

Optionally, the raking device 1010 may include other concrete surface working devices or elements which are substantially equivalent to the function of the flotation roller 1020 in FIGS. 29A-C, without affecting the scope of the present invention. For example, a raking device 1010' may include a floating pan 1020' (FIGS. 30A-C), or a raking device 1010" may include a floating track 1020" (FIGS. 31A-C). The floating pan 1020' of raking device 1010' may be dragged along and over the uncured concrete surface via a worker pulling at the handle 1014a in the direction A (FIG. 30B), while the rake or grade setting member 1012 is adjusted relative to pan 1020' to set or establish the desired grade. Similarly, with respect to raking device 1010", a worker may pull (in the direction A shown in FIG. 31B) the raking device over the concrete surface (with both rollers of the floating roller track 1020" being generally freely rotating as the roller track is pulled or moved over the concrete surface), while the rake or grade setting member 1012 is adjusted relative to floating track 1020" to set or establish the desired grade. Alternately, one of the rollers of the floating track 1020" may be driven via a drive motor (not shown) to assist the operator in moving the raking device 1010" over the uncured concrete surface, without affecting the scope of the present



invention. The raking devices 1010' and 1010" are otherwise substantially similar to the raking device 1010 discussed above, and are shown in FIGS. 30A-C and 31A-C with the same reference numbers for the other components, such that a detailed discussion of the raking devices and components will not be repeated herein.

5            Optionally, the raking device 1010 may include other concrete surface working devices, such as a vibrating beam or member or a powered roller or the like (optionally, a powered roller may be rotated in a direction opposite of travel to finish the concrete surface), without affecting the scope of the present invention. It is further envisioned that an auger may be provided in front of the rake, to further cut and establish the desired grade of the  
10 concrete surface, without affecting the scope of the present invention.

          The raking device of the present invention thus provides for reduced operator effort to rake placed concrete to a desired grade. The grade may then be set in response to a laser receiver and laser plane technology, so that the need to estimate the grade by visual inspection or looking at adjacent forms may be obviated. The raking device of the present  
15 invention provides for an initial grade setting process, whereby initially raking the placed concrete closer to the desired grade may reduce the efforts and improve the accuracy of subsequent concrete working processes.

          Although many of the screeding devices of the present invention are each shown as having a vibrating beam or member which is vibrated in response to rotation of eccentric  
20 weights having their axes of rotation oriented generally vertically or generally normal to the plane of the surface of the vibrating beam which contacts the uncured concrete, other vibrational devices may be implemented without affecting the scope of the present invention. For example, it is envisioned that the axes of rotation may be vertical, horizontal, angled, or skewed, to provide vibration at least partially in the vertical direction or entirely in the  
25 horizontal direction as well. It is also envisioned that both the vibrating beam and the vibrating device may be angled from horizontal along the direction of travel of the screeding device. This would allow for some fore/aft vibration of the vibrating beam against the uncured concrete as the screeding device is moved along and supported on the uncured concrete surface. It is further envisioned that the vibrating member may be vibrated via any  
30 other vibrational device, such as at least one eccentric weight rotating about a generally horizontal axis along the vibrating member, or a pneumatic vibration device, or any other means for vibrating the member or beam, without affecting the scope of the present invention.

It is further envisioned that various devices may be implemented at the screed head of the screeding device of the present invention. For example, the screed head may include a vibrating beam, a plow or an auger or may include any combination of a vibrating beam, a plow and/or an auger for grading, leveling, smoothing and/or screeding the uncured concrete surface. Optionally, the screed head may include a leveling roller or a spinning tube, which may be rotatable to roll over the concrete surface to level and/or smooth the surface. Optionally, the leveling roller may be of the type disclosed in commonly assigned, U.S. pat. application, Ser. No. 10/166,507, filed June 10, 2002 by Somero et al., entitled CONCRETE FINISHING APPARATUS (Attorney Docket SOM01 P-320), which is hereby incorporated herein by reference.

Therefore, the present invention provides a lightweight, easily maneuverable screeding device which is operable to consolidate, smooth, level and/or screed uncured concrete, and is ideally suited for use on elevated deck surfaces. The screeding device of the present invention avoids the need for using metal stands or for manually creating wet screed pads in the uncured concrete in advance of the screeding operation, because the screed head essentially creates its own continuous wet screed pads as the screeding device is moved or pulled over the uncured concrete by an operator. The screeding device is easily movable, steered and/or pulled by an operator over the uncured concrete surface, while the vibrating beam or member vibrates to smooth and compact the concrete at the surface as it is supported thereon. A strike-off plow or other grade setting device is positioned along a forward edge of the vibrating beam to establish or cut the grade of the uncured concrete to a desired grade or level. The weight of the screeding device at least partially rests upon the uncured concrete surface and may include no wheels with only an operator providing partial support, a single wheel, or preferably a pair of wheels, for at least partially supporting components of the screeding device and for enhancing mobility and maneuverability of the screeding device. Optionally, the wheels may be powered or driven to further enhance the mobility, maneuverability, work output, and usefulness of the screeding device.

Optionally, the level or elevation of the plow or grade setting device may be automatically adjusted in response to a laser plane using laser receivers or optionally a laser-guided 3-D reference system for vertically adjusting the grade setting device to the desired grade height. The screeding device may also or otherwise provide a visual indicator to the operator as to the current status of the grade. Optionally, the screeding device may include a concrete moving device, such as an auger or other means for engaging and moving excess uncured concrete to either or both sides or just ahead of the screeding device as the screeding

device is moved through the uncured concrete. The concrete moving device may be implemented along a forward edge of a strike-off plow, which cuts or establishes the desired grade height, or may be implemented on a forward edge of the vibrating beam without a strike-off plow, whereby the concrete moving device is operable to cut or establish the  
5 desired grade height of the uncured concrete as the screeding device moves along and through the uncured concrete.

Changes and modifications in the specifically described embodiments may be carried out without departing from the principles of the present invention, which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of  
10 patent law.